Vegetable and field crop rooting depths and lateral root distances
Compiled by Allen Dong
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Table 1: vegetable crop maximum rooting depth, lateral root distance from crown of plant and working root depth at maturity, compiled from Root Development of Vegetable Crops, by JE Weaver and WE Bruner, 1927 (free download from http://soilandhealth.org).

Vegetable crop	Variety	Age or date when root data collected	Root depth x lateral root distance, feet	Working root depth feet
asparagus		6 year old	10.5 ft deep x 6 ft lateral	4.5'
beans, dry	Wardwell's Kidney Wax	5-Aug	3.8 x 2.5'	3'
beans, dry	Burpee's Bush Lima	25-Aug	5.5 x 4'	3.7'
beet, table	Edmand's Blood Turnip	1st yr 12 Aug	11 x 4'	7'
cabbage	Copenhagen Market	1st yr 4-Aug	7.8 x 3.5'	5.2'
cabbage	Early Flat Dutch	24-Jun	3.8 x 2.7'	
cantaloupe	Rocky Ford	24-Jul	3.7 x 15'	
cauliflower	Early Snowball	1st yr 19-Jul	4.5 x 2.5'	(3')
carrot	Chantenay	1st yr 12-Aug	10 x 2.3'	7'
chard, Swiss		1st yr 28-Jul	7 x 4.4'	(6')
corn, sweet	Stowell's Evergreen	late Aug	5.7 x 3.5'	4.2'
cucumber	White Spine	22-Aug	4 x 7'	3.7'
eggplant	Black Beauty	3-Oct	7 x 4'	
garlic		12-Jun	2.5 x1.5'	
horseradish		10 yr	15 x 3.5'	(12')
kohlrabi	Early White Vienna	1st yr 13-Aug	8.5 x 3.3'	7'
leeks	Large London	26-Jul	2.5 x 1.7'	(2')
lettuce	Early Prize Head	seed set 13 Jul	7.5 x 1.5'	5'
okra	Mammoth	22-Jul	4.5 x 6.6'	(4')
onions, dry	Southport White Globe	21-Aug	3.2 x 1'	2.7'
parsnip	Hollow Crown	1st yr 5-Oct	9 x 3'	
parsley,	Champion Moss Curled	1st yr 5-Aug	4 x 1.5'	
peas, fresh	Telephone	11-Jul	3.2 x 2'	(3')
pepper	Bull Nose	17-Jul	4 x 3'	(4')
potato, Irish	Early Ohio	8-Jul	5 x 2.5'	3'
potato, sweet	Yellow Jersey	3-Oct	5.7 x 3'	4.2'
pumpkin	Small Sugar	24-Aug	6 x 17.5'	(2.5')
radish	Early Scarlet Turnip White	flowering 13-Jul	7.2 x 4.1'	(4')
rhubarb,		4th yr summer	10 x 4.7'	(8')
rutabaga	American Purple Top	5-Sep	6.2 x 1.5'	5'
spinach	Curled Savoy	seed set 10-Jul	6 x 1.2'	(4')
squash, C. maxima	Golden Hubbard	21-Aug	6 x 19'	(2')
tomato	John Baer	13-Aug	5 x 5.5'	3.5'
turnip	Purple Top Globe	5-Oct	5.5 x 2.5'	5'
watermelon	Kleckley Sweet	26-Jul	4 x 21'	(2.5')

Table 2: field crop maximum rooting depth, lateral root distance from crown of plant and working root depth at maturity, compiled from JE Weaver, 1926. Root Development of Field Crops (free download from http://www.soilandhealth.org).

Field crop	Variety	Age or date when root data collected	Root depth x lateral root distance, feet	Working root depth, feet
alfalfa		2nd yr Jun	12 x 1.5'	
barley	Manchuria	grain ripe	6.5 x 1'	(3.5')
beet, sugar	Kleinwanzlebener	1st yr Sept	6 x 2'	
clover, red		2nd yr	10 x 1.5'	
clover, white sweet		2nd yr	8 x 1.5'	
corn, field	Iowa Silver Mine	2-Sep	8 x 4'	3.3
oats, spring	White Kherson	at harvest	5 x 0.8'	2.5'
potato, Irish	Early Ohio	8-Jul	3.8 x 2.5'	3'
rye, winter	Rosen	at harvest	5 x 0.9'	4'
rye, winter	2nd site, silty clay loam soil		5.2 x 1'	4.7'
rye, winter	3rd site, sandy loam soil		7.5 x 1.2'	5'
sorghum	Black Amber	maturing seeds	6 x 3'	4'
sunflower	Russian	21-Jul	9 x 5'	4'
wheat, spring	Marquis	harvest 15-Jul	5 x 1'	3.5'
wheat, spring	at Burlington, Colorado, dry farmed		2.7 x 1	
wheat, winter	Kanred	harvest 15-Jul	6.2 x 0.7'	4.4'
wheat, winter	2nd site, clay intermix at 2.3' depth		4.7 x 0.7'	3.2'
wheat, winter	3rd site, deep loess silt loam subsoil		7.3 x 0.7	4.9'

Notes:

1. Root depths and lateral distances of vegetables were from crops grown to maturity at Lincoln, Nebraska, and Norman, Oklahoma, USA. The Nebraska site had friable silt loam soil; easily worked to depth greater than 12 feet; earthworm burrowed to a depth of 8 feet; average annual precipitation of 29 inches; and 21.6 inches of rainfall occur during April to September. The Oklahoma site had fine sandy loam soil; average annual precipitation of 39 inches; and 24 inches of rainfall occurs during April to September. At the beginning of the growing season, soil moisture was available for plant uptake throughout the crop rooting depths at both locations. Crops were grown without irrigation but receive rainfall.
2. Field crop data were collected from crops grown in Lincoln, Nebraska; except for sugar beet and a spring wheat test site, they were from Colorado.
3. The working depth is a depth to which many roots penetrate and considerable absorption must take place. Numbers without parenthesis were explicitly stated as 'working depth' by the authors. Numbers in parenthesis were inferred from the authors description (soil volume thoroughly occupied by roots), but they did not explicitly state 'working depth'. No working depth was inferred for crops with root density that gradually shifts from ‘thoroughly occupying a soil volume’ to ‘sparse root density’.
4. Plant root depth and lateral distance are affected by soil texture, structure, compaction, aggregates, fertility, water content and organic matter content. Table 2 provides examples of this: spring wheat grown at Burlington, Colorado with dry subsoil at 2.7 feet below the surface had a corresponding rooting depth of 2.7 feet. Winter wheat grown in an area with compacted subsoil at 2.3' below the surface reduced the maximum rooting depth to 4.7' at the ‘2nd wheat site’; whereas deep loess subsoil yielded a 7.3' rooting

depth at the '3rd wheat site', both within 2 miles from the main Nebraska test site. Winter rye grown at 3 different sites in Nebraska with different soil profiles had different rooting depths. Weaver and Bruner data are approximations when applying other soils.

5. Plant rooting depths for irrigated crops are available on the internet; however, crops under light frequent irrigation develop shallower roots compared to crops with infrequent or no irrigation.

Implications for Oregon dry farm test plots:

1. Pumpkin, winter squash and watermelon can have lateral roots extending 17.5 to 21 feet from crown of plant. Planting dry farmed squash and watermelon within lateral root distance to adjacent irrigated crops will yield misleading results about dry farmed squash and watermelon.
2. Different crops grown within lateral root distances of each other will interfere with assessment of their water use measurements.
3. Grass walkways between crop rows will extract water stored in the soil profile below the grass. Grass may send lateral roots into the crop row; and crops may send lateral roots below the grass walkway. Grass walkways should be removed as soon as possible in spring, but no later than when grass evapotranspiration (ET) exceeds rainfall.
4. For normal monthly rainfall and normal monthly grass ET, the walkway vegetation should be removed by April or early May, for Aurora, Corvallis, and Forest Grove, Oregon; sometime in March or early April for Medford, Oregon. This is determined using monthly grass ET and rainfall data. Monthly grass ET data were obtained from AgriMet http://www.usbr.gov/pn/AgriMet.html > crop water use information > Monthly Average Reference Evapotranspiration; and convert ET(alfalfa) to ET(grass) by dividing ET(alfalfa) by 1.2. Monthly rainfall data are from www.usclimatedata.com. Yellow highlights when the normal monthly grass ET nearly equals normal monthly rainfall.

	March		April		May	
Aurora, Oregon	1.7"ET	4.2" rain	2.8"ET	3.1" rain	4.2" ET	2.3" rain
Corvallis	1.9"	4.4"	2.9"	2.9"	4.4"	2.3"
Forest Grove	1.7"	4.7"	2.7"	3.1"	4.3"	2.2"
Medford	2.0"	2.2"	3.1"	1.6"	4.9"	1.4"

5. Nearby trees can send roots 100 feet or more from the trunk and extract soil water below the surface. Dry farm test plots within range of tree roots will be adversely affected.
6. Question: should the volume of soil explored by roots be calculated using lateral root distance and working root depth, or lateral root distance and maximum root depth; should planting density for dry farmed crops be calculated based on the working root depth or the maximum root depth? A conjecture here, the working root depth is where crop yield counts, thus calculations should be based on the working root depth. The maximum root depth is a plant survival trait allowing plants to survive but deep roots below the working root depth does not contribute significantly the marketable yield for the farmer. There are several basic rooting systems. Pancake rooting system has shallow roots with large lateral distances. For example, squash have 19 feet lateral roots with 2 feet working depth and a 6-foot tap root. Most of the water and nutrients are extracted from the pancake layer. Calculations of soil volume explored by roots using the lateral root distance and working root depth would underestimate the soil volume; whereas using maximum root dept would overestimate the soil volume explored by roots. Turnip, pea and alfalfa have cylindrical root systems; the working root depth is nearly the same as the maximum root depth and calculation of the volume of soil explored by roots using working root dept is nearly the same as using maximum root depth. Carrot and parsnip have parabolic or inverted cone root system; the difference in calculating soil volume explored by roots using working root depth or maximum root depth is between that for a pancake and a cylindrical root system.